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trees habitually grow most on the side on which the most favoring influences predominate. On the sea-coast the trees naturally grow most freely on the land side.

The following gentlemen were elected Resident Fellows, viz.: —

Professor Henry W. Torrey of Cambridge, in Class III., Section 3.

Rev. N. L. Frothingham, in Class III., Section 4.

Benjamin A. Gould, in Class III., Section 2.

E. A. Sophocles, in Class III., Section 2.

Dr. C. H. F. Peters, in Class I., Section 2.

Henry James Clark, in Class II., Section 3.

Four hundred and thirty-third meeting.

December 9th, 1856. — ADJOURNED QUARTERLY MEETING.

The Academy met at the house of the President. The President in the chair.

The Corresponding Secretary read letters from the Rev. N. L. Frothingham, accepting the Fellowship; from the Imperial Academy of Sciences, Vienna, March 10th and April 15th, acknowledging the receipt of the Academy's publications ; from the Zoölogical and Botanical Association, Vienna, May 10th; the Royal Society of Sciences at Upsal, November 16th, 1855; the Royal Prussian Academy of Sciences, Berlin, March 6th ; the Natural History Association of the Prussian Rhine Countries and Westphalia, Bonn, January 12th; the Imperial Geological Society, Vienna, March 20th; the Imperial Academy of Sciences, Vienna, May 23d and July 16th, presenting their various publications; from the Society of Physics and Natural History, Geneva, March 11th, in acknowledgment of the receipt of the Academy's publications, and presenting its own, with a circular, offering the fifth annual botanical prize on the foundation of De Candolle.

The President read a paper on the probable cause and nature of the death of Pliny the Elder, taking the ground, in opposition to the commonly received opinion, that he died of apoplexy, and not of suffocation.

A discussion arising upon the nature of the effluvia, ashes, &c., emitted by volcanoes, Dr. Hayes remarked, that eruptions were of a mixed character, distinguished by lava overflows, sublimations, and chloridic and aqueous exhalations in some cases, while in others the presence of atmospheric air and vapor of water in large quantity gave rise to sulphurous acid fumes, and sulphydric gases, with sulphur depositions. Regarding the account of the death of the elder Pliny as remarkably explicit in details, he thought the statement in relation to emission of sulphurous fumes at that time as in accordance with present knowledge on this subject, and yet as in no wise opposing the interesting view which has just now been presented of the cause of his death. The abundant source of sulphur fumes and sulphydric gases is the solfa-taras, which, generally in action, exhibit during eruptions their highest activity; and these existed then, and now exist, in the low grounds in the vicinity of Vesuvius, changing their places as the decompositions on which they are dependent proceed. Solfa-tara action can hardly be classed with true volcanic action, although primarily dependent on it. It is a slow combustion, taking place among the aggregates formed at the time of previous volcanic action, requiring the presence of water for continuing it. The earliest history of Vesuvius presents it as a solfa-tara consuming the lava rocks of an earlier period, and its cones of later dates have been craters of elevation, subject to degradation, which has several times occurred. Pliny, at the time of his death, was at Stabiæ, where were hot volcanic waters along the shores, marking the points of solfa-tara action. The sulphur of commerce is derived from the deposits formed by solfa-taras, and its immense quantity affords some estimate of their extent and antiquity.

Mr. Everett followed, illustrating the changes in locality of the solfa-taras, from his own observations, after an interval of a few years had elapsed. He also stated as his experience, that the crevices of the lavas, in the vicinity of the crater of Vesuvius, emitted sulphur fumes ; the napkin containing eggs, while being cooked, was coated with sulphur.

Dr. Pickering remarked, that, so far as his observations extended, sulphur vapors were abundant in lava crevices, wherever vapor was emitted. Referring to the great lava lake of the volcano of Hawaii, he said there was no perceptible smell of sulphur near its surface.

The President, Dr. Peters, and Professor Horsford also took part in the discussion.

The President expressed an interest in the question of the origin of volcanic ashes, referring to the fact of their being carried by winds and dispersed over extended areas at the time of eruptions ; falling on vessels at sea far from any land.

In answer to an inquiry from the President as to the nature of volcanic ashes, Dr. Hayes replied, that they are the finely divided parts of broken down volcanic aggregates, having generally the composition of silicates of alumina, slightly contaminated by other silicates. To have a clear view of the origin of these ashes, it is necessary to consider that volcanic action, under its differing intensities, either fuses together or merely compacts assemblages of divers minerals, including sulphur compounds of metals and of earths. This action is often aqueous or hot-water action, and the rocks formed *include the elements of their own destruction,* on exposure subsequently to the air and moisture. Thus one of the most solid is the true Augitic Trachyte, which will not resist exposure to a New England atmosphere one year, without crumbling and disintegrating. Craters of elevation are composed in large part of this rock, often covered by true fused lavas in part. The latter, at the points near their source, are tolerably compact, but as they pass along the surface, they become tumefied and scoriaceous, and hence subject to decomposition. When the sulphurets have been engaged in the trachytes, decomposition commences soon after exposure to humidity, attended by the emission of vapors and acid fumes, which corrode and decompose all the superincumbent mass of rock, more or less. In craters of depression, as water can more copiously fall in, this decomposition of compound aggregates proceeds with great rapidity, and to great depths. The changes resulting from the chemical action thus established are not merely mechanical; salts more or less soluble form, and are dissolved in the escaping waters, while the rocky masses are reduced to their insoluble, finely divided, proximate elements. Few of the compound silicates resist this action; thus soda felspar, which generally is found in trachytes, and in the laboratory, decomposes slowly, but rapidly yields its silicate of soda to the acid and aqueous vapors, and solfa-tara is soon reduced to a mixture of silicic acid and pipe-clay. From this brief statement of facts, it becomes apparent that every volcanic focus becomes covered to a great depth with finely divided materials, resulting from rock decomposition, and any succeeding eruption must be preceded by a removal of this matter in the way of upheaval. The narratives of the eruptions of Vesuvius, so remarkable for graphic description, show that, after periods of repose, the first efforts of reawakened vigor are expended on the materials covering the surface. One of the most instructive examples, also, is that of the eruption, so called, of the volcano Morne Ronde, on the island of St. Vincent, in 1792, the marks of which I have examined. This, as is well known, is one of the volcanic vents of the Windward West India Islands, and its resumption of activity was preceded by no preliminary efforts. The inhabitants of the island were roused from their slumbers at about 2 A. M. by a terrific convulsion, the earth swaying under their feet, while the atmosphere, suddenly displaced, was rushing in opposing currents from all directions, attended by deafening reports. By one sudden explosion, the top of the mountain, about three thousand feet high, lost several hundred feet in height, while, as afterwards appeared, a cavity of about eight hundred feet deep was formed. The larger masses of the covering material rolled down its base, while the more finely divided part was carried upward, falling into the sea, — nearer or farther off in proportion to the size of its fragments. The finer parts rose above the current of the trade winds, and, taking the upper and opposite flow, spread over the sea and the island of Barbadoes, obscuring the light of a tropical sun, and causing the greatest consternation on land and sea. This ash I have examined from several parts of its course, and it differed in no respect from the fine parts of the trachyte, undergoing decomposition by atmospheric agents on the spot. There followed after this explosion no flow of lava, but a shower of rude balls of half-fused, tumefied trachyte, succeeded by fragments of rocks, earths, and finally mud and water. The final action took place obviously within the crater, formed more than eight hundred feet below the surface of the top of the mountain, and resulted in the production of a regular cone of sand and gravel, which remained. Twenty years after (1812) a similar explosion took place, and the point of greatest interest is, that a new centre of action appeared. A smaller crater was formed, so near the older one that the rim of the later one breaks its continuity. The action which followed the dispersion of the disintegrated covering in this case was of a kind among the most remarkable on record. A large part of the force was expended in discharging from the crater rocks broken into fragments, from the size of a cubic inch to that of grains of sand; nearly every fragment and grain being bounded by straight lines, square or rectangular, with sharp angles and edges. As the volcanic vents of the West Indies, and indeed whole islands, have been elevated from below a deep ocean which surrounds them, they offer the best examples of that secondary effect, resulting from chemical action taking place within the aggregates formed, which I could adduce.

Professor Horsford suggested that, as the volcanic ashes are silicates of alumina, it might be possible for the mixed chlorides of aluminium and silicium to be shot as a bolt from a crater, and at a distance from that point find moisture and atmospheric oxygen to convert them into oxides and hydrochloric acid; when they would unite to form silicate of alumina.

Dr. Hayes replied, that, if such a supposition were for a moment entertained, the mixed chlorides could only form hydrochlorates under the conditions, and if the mixed metallic bases were to be oxidized in union, a crystallized silicate of alumina would result, while volcanic ashes under a microscope are either scales with rough imbrications, or feathery forms, such as we every day see in decomposing trachytes and micaceous rocks, water being present.

In reply to the President, Dr. Hayes added, that the chloridic sublimates are not true chlorides usually, but hydrated compounds which do not form solid crystals, being transported in a vesicular state by watery vapor, which, with atmospheric oxygen, is always present in the gases evolved during the most active eruptions; hence true chlorides, excepting common salt, are rarely found.

Dr. A. A. Hayes made the following communication, "On some Points of Chemical Interest, connected with the Manufacture of Ductile Iron by the new Process of H. Bessemer," and exhibited some specimens.

"In calling the attention of the Academy to a part of the process for obtaining nearly pure ductile iron from crude products of the iron-ore furnace, which has of late excited much interest among those engaged in the iron manufacture, it is not my intention to enter upon the economical or technical part of the subject at this time. It is well known that Mr. Bessemer has based his improvements on the startling novelty of making crude iron nearly pure, *without the aid of fire from carbonaceous matter.* In considering the ordinary mode of refining crude iron, the final operations being performed on crude pig, or on partially refined pig-iron, we have as one of the conditions of success the application of an intense heat, and the presence of more or less atmospheric oxygen, necessary to maintain the required degree of fluidity in the mass of iron, and to burn out the carbon and other impurities present. As the iron loses its carbon and other extraneous substances, it becomes less fusible, and the workman, stirring the mass as it begins to lose its fluidity, gathers into rough masses the aggregated particles, which are always spherical in general form. From the masses, which are very porous and unequal, a bar of regular form is obtained by the usual means of pressing, or hammering and rolling.

"There is in this process strictly a segregation of particles of pure iron from the crude mass, which, under the agitation of stirring, unite to form rounded aggregations, and the heat of the furnace being increased, the separation of pure iron continues, until the melted impurities alone remain. The change of crude to pure iron is accompanied by the *production* in part of the impurities which remain; they are not educts. Aside from the loss of carbon in the form of carbonic oxide, the phosphorus and sulphur, — which my experiments have proved are always united to the metallic bases of the earths or alkalis, — with these bases, burn into oxidized products; while the silicium and a portion of the iron, also oxidized, form the melted slag, or cinder, as an additional foreign matter. To the loss of impurities we must also add the weight of iron burned in forming secondary products, so that, if the operations were performed on crude iron containing ninety-two per cent of pure iron, no more than eighty-two per cent of malleable iron will be obtained. By the method of Bessemer, crude iron in a melted state is exposed in a nearly closed receptacle to jets of air forced into and under the fluid, and it is alleged that such an excess of heat is produced in the process, 'that the metal continues to boil even after the blast has ceased.' The direct statement is made, that 'the air, dividing into globules, and diffusing itself among the particles of fluid iron, and thus coming in contact at numerous points with the carbon contained in the crude iron, and producing thereby a vivid combustion,' and the same action is implied in other parts of Mr. Bessemer's patent-specification.

"Now it is well known to chemists, that the combustion of the carbon of crude iron *cannot take place under the conditions.* This carbon exists in gray iron in the allotropic state of graphite, and is not combustible even alone, when exposed highly heated to a current of atmospheric air. We burn it in the laboratory by the application of oxygen in some condensed state only. The proper chemical explanation of this point is a very simple one. Iron, which is a highly combustible body at ordinary temperatures, has its attraction for oxygen enormously increased by the heat of fluidity, and in combining with this element, the heat disengaged is ample for carrying the temperature of the mass still higher. A portion of oxide of iron being formed, the mechanical motion imparted by the jets of air favors the contact of the oxide with the carbon, *which then burns with the condensed oxygen of the oxide of iron.* The products of this combustion, arising from the mingling of oxide of iron and graphitic carbon and pure graphite, are two, — pure iron, and carbonic oxide; the former uniting with the mass, the latter escaping as gas, and burning in the atmosphere, or even with any oxide of iron it meets with in the mass. A moment's consideration of the operation shows that the combustion of the iron at the first stage leads to the separation of the carbon as carbonic oxide, and a reduction of the oxide formed to pure iron. Silicium, phosphorus, cyanogen, and sulphur, the bases of the alkaline earths, and interposed slags are oxidized and removed as fusible compounds in the same way, *while the pure iron assumes the crystallized state.* The combustion of the iron raises the temperature of the acting bodies far above the initial point, while the reduction of the oxide of iron formed diminishes in a corresponding degree this temperature. Were the conditions of the experiment such that the oxide formed from the iron burned was equivalent to converting the carbon into carbonic oxide only, at the moment the oxide of iron became pure iron, then no increase of temperature would be noted, and the cooling influences of the surrounding medium would cool the acting bodies below the initial temperature. Hence, it is essential that more than an equivalent of iron should be burned, and a loss of this substance must take place, so that the operation of purification by the new process is carried on by substituting *iron as fuel* for carbon consumed in the ordinary process. Assuming six pounds of carbon to exist in a sample of crude iron containing ninety-two pounds of pure iron in one hundred pounds, then *twenty-eight pounds of iron* must be burned to oxide, and the six pounds of carbon will exactly reproduce the twenty-eight pounds of iron, leaving ninety-four parts of iron deprived of carbon. But the practical result differs from this statement, inasmuch as a positive loss of at least ten pounds of iron occurs; and in explaining the increased elevation of temperature, we neglect that portion of the iron which, having been burned and again reduced, adds to the mass, and keep in view the effect of the combustion of ten pounds of iron lost in the operation at the high temperature attained. Accurately, some addition to the temperature is made by the combustion of other bodies present besides carbonic oxide, but there are also sources of expenditure ; leaving as useful effect the amount of heat generated by ten pounds of iron burned, from every one hundred pounds of melted iron taken.

"I believe this combustion, going on momentarily with the reduction of the oxide, is sufficient to afford the excess of heat required to maintain the temperature of the mass of iron above the initial temperature for the short time of thirty or forty minutes, during which the conversion takes place in a nearly closed vessel.

"The other point in this connection is the condition of the pure iron at the moment of its conversion. As this is most important to a correct conception of the practical bearing of the method, it was deemed necessary to describe briefly the ordinary mode of puddling iron, and reference is now made to that part where it is stated, that, as the iron becomes pure, it is less fusible.

"In ordinary, this less fusible part is 'gathered,' and forms 'puddle-balls'; if not thus removed, and time sufficient were allowed, the whole charge would become consolidated, and could not be removed. In the new method, the jets of air agitate or 'boil' the fluid iron, and yet this solidification does not proceed, and it has been assumed that the acting temperature is so high that the pure iron becomes fluid. No evidence has been presented to sustain this assumption, and it has been shown above, that there is no source of heat present adequate to cause such fluidity. All the specimens of a suite illustrating the manufacture, prepared under the eye of Mr. Bessemer, show that such heat of fluidity is unnecessary." (Dr. Hayes exhibited these specimens, which illustrated, step by step, the conversion of crude iron into pure iron, and the subsequent production of the interwoven particles forming wrought-iron, and the most finished specimens of laminated sheets.)

"These specimens prove that the molten mass of pure iron is not a *liquid iron*, but a semi-fluid composed of crystals of pure iron, which, in accordance with the laws of crystallization, have withdrawn from the fluid, merely wet by the fluid iron present, and rendered pultaceous by the carbonic oxide gas entangled. This physical condition of the iron is represented by particles of hail mixed with a small proportion of water, or more exactly by the mixture of crystals of sugar and concentrated sirup, as it is filled into the forms; such a mass will flow and take sharp impressions in the moulds, while its texture on cooling is highly crystalline and porous. Although the iron in this state is as pure chemically as any bar-iron, its mechanical state does not assimilate it to malleable iron, and the ingots rarely present the compactness of cast-iron of the coarser qualities. A careful examination of the specimens suggests the conclusion, that much of the character of fluidity is also due to the presence of the engaged carbonic oxide, which, like any gas disengaging from a dough-like semi-solid, causes it to flow.

"This mechanical constitution of the pure iron removes the difficulty which every iron-master must have conceived to exist, in the descriptions of the new method heretofore published, and it will be seen that the effects produced in the old and new process are strikingly similar; while the fuel in the one case is iron, in the other the ordinary coke or coal. In removing the iron from the furnace, the puddler depends on forming a rude porous aggregate, while Mr. Bessemer, by a refined mechanical agitation, converts the whole into a semi-solid, crystalline mass, full of gas-bubbles, which flows from an inverted vessel, and takes the forms of the moulds."

Mr. Charles Jackson expressed a doubt as to the practical value of the new process, and adduced the significant fact, that it had not in the least affected the price of iron in the market, nor the value of iron-works.

Dr. Hayes rejoined, that he had presented to the Academy only the interesting chemical points, avoiding the economical bearing of the discovery. He was, however, prepared to discuss this fact, in view of its importance to the English, rather than to the American manufacturer.

Professor Gray presented, in the name of Dr. Engelmann, the following

"*Corrections and Additions to the Synopsis of the Cactaceæ of the United States.*

"On p. 279, the var. *minor* of *Cereus dasyacanthus* should be cancelled, and after *C. longisetus*, p. 280, the following added: —

"9½. C. Rœtteri, E. in B. C. R.: ovato-cylindricus, 10 – 12 costatus; areolis ovato-orbiculatis; aculeis e basi bulbosa subulatis-rubellis apice obscuris exterioribus 10 – 15, interioribus 2 – 5 robustioribus sub-brevioribus; floribus subterminalibus magnis purpureis; bacca subglobosâ; seminibus tuberculatis.

"El Paso, southward to the Sandhills; fl. April. — Stem 5–6 inches high; spines 4–8 lines long; flower 2½–3 inches long. Similar to *C. dasyacanthus*, from which it is distinguished by the fewer ribs, fewer and stouter spines, purple flowers, smaller fruit, and larger seed. This species is intermediate between the *Pectinati* and *Decalophi.*

"After *Opuntia setispina*, p. 294: —

"O. Pes Corvi, Le Conte, Mss.: articulis parvis teretiusculis; pulvillis subconfertis setas paucas breves graciles flavidulas gerentibus plerisque armatis; aculeis binis ternisve gracilibus sæpe basi compressis tortisque; flore flavo minore.

"Sandy coast of Georgia, *Major Le Conte*, and Florida, *Dr. Chapman.* — Joints not much over an inch long, and half as thick. Spines 1–1½ inches long, straight and slender. Flower 1½ inches in diameter. Ovary only with 5 areolæ; stigmas 5. — In the shape of the joints this curious little species resembles *O. fragilis*, but in other respects it seems intermediate between *O. vulgaris* and *O. tenuispina.*"

Professor Agassiz addressed the Academy on the general characters of Orders in the classification of the animal kingdom. Orders, he said, are natural groups characterized by complication of structure. There are groups, however, constituting orders, which do not come under this definition; hence he concludes that the different classes of the animal kingdom do not all admit of the same divisions. Professor Agassiz illustrated his views by the different orders of Echinoderms. In conclusion, he remarked, that orders are of different kinds, some synthetic, some prophetic, others graduated.

After nomination by the Council, —

Laurens P. Hickok, D. D., President of Union College, Schenectady, was elected an Associate Fellow in the Section of Philosophy and Jurisprudence.

Dr. George B. Wood and Dr. Isaac Hays, both of Philadelphia, were elected Associate Fellows in the Section of Medicine and Surgery.

John Stuart Mill, of London, was elected a Foreign Honorary Member in the Section of Political Economy and History.

Manuel J. Johnson, Director of the Radcliffe Observatory, Oxford, was elected a Foreign Honorary Member in the Section of Practical Astronomy and Geodesy.

Four hundred and thirty-fourth meeting.

January 13, 1857. — MONTHLY MEETING.

The Academy met at the house of the Hon. Robert C. Winthrop. The President in the chair.

The Corresponding Secretary read letters from Dr. George B. Wood, Dr. Isaac Hays, and Laurens P. Hickok, accepting Fellowship; from the Essex Institute, the American Antiquarian Society, the Royal Institution of Great Britain, the Society of Arts, Manufactures, and Commerce, Professor Faraday, and Sir Charles Babbage, acknowledging the receipt of the Academy's publications; from the American Oriental Society, acknowledging the same, and presenting Vol. V. No. 2 of its own Journal; and from the Société Nationale d'Agriculture, &c. de Lyon, and the Académie Nationale des Sciences, &c. de Lyon, presenting their publications.

Professor Agassiz reminded the Academy of the recent death of a distinguished associate in the following words: —

"It is the first time we meet since the death of the Hon. Francis C. Gray, one of our fellow-members. Though there are others longer acquainted with Mr. Gray than myself, who are better qualified to speak of his general merits, allow me to take this opportunity to make known to you some incidents relating to the last objects upon which his mind was seriously engaged. I have not had the happiness of knowing Mr. Gray intimately for many years; but for the last two years peculiar circumstances, which are among the most fortunate of my life, have brought me gradually nearer to him, and enabled me to become more closely acquainted with his extensive attainments, and the great powers of his vigorous and clear intellect, and to appreciate fully the kindness of his feelings, and his unbounded benevolence.

"There is hardly any field of intellectual activity which did not